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Availability of UK climatic data for use in simulation

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Building Research Establishment

Building Environmental Performance Analysis Club

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The Building Environmental Performance Analysis Club (BEPAC) was formed in late 1987 to provide a forum for all concerned with the prediction of environmental conditions in building, especially those interested in the application and development of computer-based methods. Its members include consulting architects and engineers, computer systems developers, government agencies and researchers from the public sector, utilities and universities. BEPAC has a wide scope, embracing thermal, visual and acoustical environmental design, with a particular interest in sharing data, methods and experience within and between these fields.

BEPAC brings its work to its members and to industry and the professions generally, through publications, meetings and workshops, and has established a number of Task Groups for detailed study of particular issues. Publications will include both **Technical Notes**, written by members on subjects of topical interest, and **BEPAC Reports**, containing recommended data sets, guidance, procedures, etc, agreed by its Task Groups and the BEPAC Committee. BEPAC also aims to represent the interests of its members on other bodies concerned with research and standardisation in the field of environmental performance.

While all currently-planned activities will be in the United Kingdom, BEPAC welcomes members from other countries. Enquiries about membership should be addressed to:

BEPAC Administration
Environmental Systems Division
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Garston
Watford
WD2 7JR

Telephone: 0923 664132 (direct dial)
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Fax: 0923 664010

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1 Introduction

The scope of this Report is limited to hourly meteorological data, commonly needed in simulation work. The characteristics and availability of data from various sources are described, and data needs of particular programs summarised.

Multi-year Datasets

Multi-year datasets will almost certainly include a representative range of weather conditions, and are therefore ideal for assessing the overall performance and sensitivities of a model, or of a building design being modelled. 'Machineable' hourly station datasets can be obtained from the Meteorological Office at Bracknell. For academic and research users, there are special rights to a set of multi-year datasets purchased as the SERC meteorological database (see Part 2). In most cases the data are copyright, which may involve charges or restrictions on use: the cost of acquiring and using multi-year hourly datasets covering the range of meteorological elements needed for simulation is likely to be substantial, and the use of shorter periods of data more practical.

Reference Years

A Reference Year (variously known as a Test Reference Year (TRY), a Typical Meteorological Year (TMY) a Standard Weather Year or an Example Weather Year) is a single year of hourly data (8760 hours), selected to represent the range of weather patterns that would typically be found in a multi-year dataset. It is intended to allow more economical simulation than multi-year datasets, and to form an equitable basis for comparing the predicted typical energy consumptions of different building designs and, in some cases, the typical performance of solar collectors.

Definition of a Reference Year depends on its satisfying a set of statistical tests relating it to the multi-year parent dataset from which it is drawn. Some groups have preferred to identify a continuous, 12-month period as typical, whereas others have applied the criteria to individual months, subsequently assembled into a composite 12-month set. Three different ways of identifying a Reference Year have been promulgated for the United Kingdom: CIBSE Example Weather Years, EC (European Community) Test Reference Years and the PCL (Polytechnic of Central London) Test Reference Year; each is described in detail in Part 2.

For even greater economy in computing time, work has been undertaken to identify hourly data for a selection of days in a year, to form a Short Reference Year (SRY). This may be a sub-set of a Reference Year, or be drawn from a multi-year dataset using similar criteria to those used for deriving a full Reference Year. The method of selecting the constituent days is to test the typicality of either a small set (eg from 3 to 7) for each month, or a larger set (14 to 16) for each season. Short Reference Years have been defined by EC and PCL, but not by CIBSE (although 'condensed statistics' based on the CIBSE Example Weather Year have been published, as referenced in Part 2).

Representative Days

Hourly data for certain weather elements have been published for three types of day in each month: clear sky, overcast and average (Page and Lebens, 1984, for Energy Technology Support Unit). Most of the radiation data were estimated by the University of Sheffield. Although given in printed form, the data are compact enough to be keyed in as computer files, although it should be borne in mind that the analyses have not produced truly co-incident data.

Recent work for ETSU has led to the selection of three types of 'design day': winter (cold cloudy), spring (cold sunny) and summer (hot sunny), which are available as hourly data files.

Another source of estimated hourly data for single days is the banded data and associated methods given in the CIBSE Guide, Part A2.

2 Nature and Availability of Meteorological Data from Various Sources

Meteorological Office Datasets

The Meteorological Office holds hourly data in several forms, devised to facilitate the many types of data transfer and analysis needed to meet its own and its customers' needs. Many details are of limited interest to the outside user, but it is useful to note certain features:

1 Data are needed for two distinct purposes - weather forecasting and climatological work - and this is reflected in the organization of the datasets:

  a Weather forecasting uses an extensive set of current and recent data covering a large part of the world, known as the synoptic database. This is used to drive dynamic models of weather systems, but because of the real-time need the data are not fully quality-checked. Data are held for at least 2 years. The synoptic database is of limited value for problems of building simulation, but can be useful if very recent UK data are required, or an urgent need arises for recent data for a foreign location.

  b Climatological work makes use of a permanent archive structured to allow many different forms of data extraction and analysis. Data are duplicated in differently arranged types of set:

    The periodic datasets, containing data from all meteorological stations, arranged month by month

    The climatological datasets, containing a chronological sequence of data for each meteorological station

  Internally the Meteorological Office uses a set of general-purpose FORTRAN sub-routines known as GPACCESS, designed to search the various labels and codes used to identify the data. Before being added to the periodic or climatological database, data are quality-checked so that doubtful values can be corrected or discarded. Because of this, and because many data are still archived from paper records, it takes about 2 months for general hourly data to reach the archive, and somewhat longer for radiation data.

2 All stations record daily data, but only a selection record at more frequent intervals, such as hourly or 'fixed-hourly' (ie, at intervals of 3, 6 or 12 hours). Daily data are held on separate files from data logged at other intervals. Fixed-hourly data conform to the format for hourly data, but with missing rows: the missing data can be interpolated if necessary to create a partly estimated hourly file.

  This file structure complicates the calculation of some climatological statistics, eg where the co-variation of a daily and an hourly or fixed-hourly element needs to be calculated. This may be significant for simulation if hourly data need to be estimated from daily data (eg hourly irradiation from daily sunshine totals) and then combined with other, true hourly data.

3 General hourly datasets (not all including radiation) with at least 10 years of data are available for 51 stations in the UK, shown in Figure 1.

4 Irradiation data are held on a separate database from other hourly data, and the time basis over which values are accumulated is different from that used for all other accumulated or averaged data (see 'Time standards for hourly data' below). This is largely for historic reasons, since radiation measuring stations were established as a separate network. There are currently 20 hourly radiation measuring stations in the UK, of which 15 measure at least global and diffuse horizontal irradiation. Of these, 5 have 10 years or more of continuous data, as do 3 stations which have now closed. 2 stations (Bracknell and Lerwick) have measured global irradiation on vertical surfaces. Details of past and present hourly stations are given in Table 1, while Figure 3 shows the locations of both hourly and daily stations.

The actual formats of the various databases are not illustrated here, since the Meteorological Office normally supplies data formatted to its customers' requirements. The Meteorological Office has 2 scales of unit charges for machineable data: a lower rate is charged for academic and other non-profit applications than for commercial uses. Contact:

Building Consultancies
Meteorological Office
London Road
Bracknell
RG12 2SZ

TEL: 0344 85 68 56 (DD)
TEL: 0344 42 02 42, X 6856 (SB)
TLX: 84 98 01
FAX: 0344 85 49 06 / 85 44 12

The SERC Meteorological Database

The SERC meteorological database was set up in 1982 to allow free access to a large block of UK meteorological data for any SERC-funded researcher having a justifiable need for it. The data were held and managed on a PRIME computer at the Rutherford Appleton Laboratory, Chilton, Didcot but, with the phasing out of this machine, SERC has decided to cease supporting the database. The licence for free use of the data remains valid, and SERC will continue to serve as a contact point for researchers interested in climatological work.

The database comprises the following multi-year sets of hourly data for 8 radiation-measuring stations:

Aberporth	1974-01-01 to 1981-12-31
Aldergrove	1974-01-01 to 1981-12-31
Bracknell	1973-01-01 to 1982-12-31
Cardington	1974-01-01 to 1980-05-31
Eskdalemuir	1974-01-01 to 1981-11-31
Kew	1962-01-01 to 1980-12-31
Lerwick	1974-01-01 to 1981-12-31
London W/C	1974-10-01 to 1981-12-31

The database contains the 11 parameters shown in Table 2, which gives the format of the hourly data files. There were also separate, summary files for a number of pre-computed climatological statistics, intended to help users identify weather trends and patterns in particular periods without having to call up the full hourly dataset. These summary files have now been discarded. Extra quality checks were made on the hourly data, resulting in a few differences between this database and the original Meteorological Office datasets. The time basis of some data in the hourly files was also changed, as described in 'Time standards for hourly data' and Table 11.

The database and management software were prepared at the Dept of Building Science, University of Sheffield, and are described more fully by Page, Gibbons and Lowe (1985). Much of the information given in the database handbook (2nd Edition, Page J K, Gibbons C J, Sharples S; 1988) remains of value, even though physical access to the data by the original protocols is no longer possible.

For further information about SERC climatological work contact:

Energy Research Support Unit
Rutherford Appleton Laboratory
Chilton
Didcot
OX11 0QX

TEL: 0235 21 900, Ext 5265
TLX: 82 159
FAX: 0235 44 58 08 or 44 58 31

Aberdeen University Meteorological Data Service

Data are held for all Scottish Meteorological Office stations, plus Culterty Field Station. The datasets are intended mainly for studies of the natural environment, and no radiation data are held: cloud amount and type are held for hourly stations, and sunshine hours for daily stations.

Hourly data are available for the following stations and periods:

Abbotsinch	1966-01-01 to 1986-12-31
Benbecula	1957-01-01 to 1986-12-31
Dyce	1957-01-01 to 1986-12-31
Eskdalemuir	1957-01-01 to 1986-12-31
Kinloss	1959-01-01 to 1986-12-31
Kirkwall	1957-01-01 to 1986-12-31
Lerwick	1957-01-01 to 1986-12-31
Leuchars	1957-01-01 to 1986-12-31
Machrihanish	1965-01-01 to 1986-12-31
Prestwick	1957-01-01 to 1986-12-31
Stornoway	1957-01-01 to 1986-12-31
Tiree	1957-01-01 to 1986-12-31
Turnhouse	1957-01-01 to 1986-12-31
Wick	1957-01-01 to 1986-12-31

Access to the data is governed by rules similar to those for the SERC database. For further information contact:

University of Aberdeen
Computing Centre
Edward Wright Building
Dunbar St
Aberdeen
AB9 2TY

TEL: 0224 27 35 15
TLX: 73 458 (UNIABN)
FAX: 0224 48 70 48

South-West Universities Regional Computer Centre (SWURCC) Meteorological Dataset

Data are held for all Meteorological Office stations in areas of South-West England and South Wales bounded on the north by a line from Aberporth to Brize Norton, and on the east by a line from Brize Norton to Hurn. Radiation data are held in the hourly data set for Aberporth, and cloud amount and type for other hourly stations.

Hourly data are available for the following stations and periods:

Brize Norton	1968-01-01 to 1984-12-31
Bristol W/C	1983-01-01 to 1984-12-31
Filton	1957-01-01 to 1980-04-30
Hurn	1957-01-01 to 1984-12-31
Lyneham	1957-01-01 to 1984-12-31
Boscombe Down	1957-01-01 to 1984-12-31
Aberporth	1957-01-01 to 1984-12-31
Milford Haven	1964-06-01 to 1984-12-31
Brawdy	1974-10-01 to 1984-12-31
Cardiff	1957-01-01 to 1984-12-31
Cilfynydd	1974-06-01 to 1984-12-31
Yeovilton	1964-09-01 to 1984-12-31
Mountbatten	1980-12-01 to 1984-12-31
Exeter	1957-01-01 to 1984-12-31
Scilly	1980-12-01 to 1984-12-31
Scilly Round Is	1983-12-01 to 1984-12-31
Gwennap Head	1971-01-01 to 1984-12-31
Culdrose	1960-12-01 to 1984-12-31
Camborne	1978-09-01 to 1984-12-31
St Mawgan	1957-01-01 to 1984-12-31

Access to the data is governed by rules similar to those for the SERC database. There is a strong preference for users to analyse their data on the SWURCC computing system, rather than export them to local systems. For further information contact:

Bath University Computing Services
Claverton Down
Bath
BA2 7AY

TEL: 0225 60 371
TLX: 44 90 97
FAX: 0225 62 508

CIBSE Example Weather Years (as selected by CIBSE and by ETSU)

The first basis for a UK Reference Year was developed by CIBSE (Holmes and Hitchin, 1978; Hitchin, Holmes, Hutt, Irving and Nevrala, 1983; Holmes, Hutt, Irving and Nevrala, 1984). To avoid discontinuities in the weather sequence, it was decided to select a continuous 12-month period rather than an aggregation of typical months, with the period starting on October 1 and ending on September 30. The parameters included in the selection process are:

Total irradiation on horizontal surface
Diffuse radiation on the horizontal
Daily mean wind speed
Daily maximum dry-bulb temperature
Daily minimum dry-bulb temperature

Daily mean dry-bulb temperature
'Infiltration number' (a function of wind speed and dry-bulb temperature).

The selection criteria are relatively simple: to reject any year with one or more monthly mean values departing more than 2 standard deviations from the long-term monthly mean, and then to reject from any remaining years those with the highest deviations from long-term monthly means until only one year remained. This process did not therefore involve analysis of multiyear hourly datasets. Selection was based on the review of up to 25 years' monthly mean data (19 years in the case of Kew). The chosen periods, for locations in England, Wales, Scotland and Northern Ireland are:

Aberporth	1972-10-01 to 1973-09-30
Aldergrove	1977-10-01 to 1978-09-30
Bracknell	1966-10-01 to 1967-09-30
Kew	1964-10-01 to 1965-09-30
Eskdalemuir	1970-10-01 to 1971-09-30
Watnall	1976-10-01 to 1977-09-30 (provisional)

In the original 1978 paper, reference is made to a calendar year satisfying the Example Weather Year selection criteria, as an alternative to the October to September period. For Kew, this is identified as 1967, and the hourly dataset 'KEW67' has been widely used in model comparison and validation. However discrepancies have been found between various copied or converted versions of the KEW67 file. The validity of existing, locally held versions should be checked before they are used, and this source of variation needs to be recognised in comparisons involving previous model results. CIBSE itself did not identify calendar years for any other location.

Recently ETSU commissioned work to select and make available a comprehensive set of Example Weather Years for the United Kingdom (Oscar Faber, 1990), for use in passive solar design studies. These have been based on the CIBSE selection procedure described above, to determine both a calendar year and an October-September year for the following 16 sites:

Region (selected location	**Source of Synoptic Data**	**Source of Radiation Data**	**Example Years**	
			Jan-Dec	**Oct-Sep**
West Scotland (Glasgow)	Abbotsinch	Dunstaffnage	1973	1972-73
East Scotland (Aberdeen)	Dyce	Aberdeen	1977	1980/81
East Scotland (Dundee)	Leuchars	Mylne	1974	1980/81
South Scotland (Eskdalemuir)	Eskdalemuir	Eskdalemuir	1973	1970/71
North Ireland (Aldergrove)	Aldergrove	Aldergrove	1977	1977/78
North-East England (Newcastle)	Boulmer	-	1979	1986/87
West Central England (Manchester)	Ringway	Aughton	1982	1984/85
Central England (Finningley)	Finningley	Finningley	1984	1986/87
West Wales (Aberporth)	Aberporth	Aberporth	1964	1972/73
Central England (Birmingham)	Elmdon	-	1973	1972/73
East Central England (Norwich)	Marham	Hemsby	1984	1981/82
South-West England (Bristol)	Lyneham	-	1982	1984/85
South-East England (Heathrow)	Heathrow	Bracknell	1980	1979/80
South-East England (Kew)	Kew	Kew	1967	1964/65
South-East England (London)	London WC*	London WC*	1979	1978/79
South-West England (Camborne)	St Mawgan	Camborne	1982	1981/82

Note: London Weather Centre dataset is incomplete and data are not available

Datasets have been compiled for the October-September years at the 15 sites (excluding LWC), to include:

Total irradiation on horizontal surface
Diffuse radiation on the horizontal
Dry-bulb temperature
Wet-bulb temperature
Cloud cover
Atmospheric pressure
Wind speed
Wind direction

For many of the sites solar irradiation was estimated from knowledge of extra-terrestrial radiation, actual irradiation where measured and cloud cover, using methods derived from EC work (Page, 1986), with further data fitting for differences in cloud cover between synoptic and radiation data sites.

These datasets will be sold on floppy disks, either to the format shown in Table 3 (adapted from the EC-TRY format), or ready-formatted for use in either SERI-RES or ESP (Tables 6 and 7). For further information contact:

FACET Ltd
Marlborough house
Upper Marlborough Road
St Albans
AL1 3UT

TEL: 081 784 5784
TLX: 88 90 72
FAX: 081 784 5700

The 6 originally defined CIBSE Example Weather Years can be also be purchased as hourly data from the Meteorological Office, as described above. The range of meteorological elements and the required format can be defined by the user, but the standard tape contains the following:

Total irradiation on horizontal surface
Diffuse radiation on the horizontal
Sunshine duration
Dry-bulb temperature
Wet-bulb temperature
Specific enthalpy
Atmospheric pressure
Wind speed
Wind direction
Rainfall amount and duration
Dew-point temperature
Vapour pressure
Relative humidity
Radiation balance
Total illuminance
Diffuse illuminance

The Example Weather Years for Aldergrove and Kew are contained in the multiyear datasets of the SERC meteorological database, although certain of the above quantities would need to be derived or estimated.

Work on the statistics of the data in the 1964/5 Kew Example Weather Year has also been published (Hitchin, 1980; Letherman and Wai, 1980 (2 papers); Letherman, Wai and Daskalakis, 1980).

EC Test Reference Years and Short Reference Years

Work was undertaken at the Danish Thermal Insulation Laboratory for the Commission of the European Communities to identify and market Test Reference Years and Short Reference Years (Data tapes and user guides by Lund, 1984 and 1985a). In contrast to the CIBSE work, selection was in terms of individual months chosen for typicality, subsequently merged into an 'artificial' calendar year. The range of meteorological elements included in the analysis was:

- Total irradiation on the horizontal
- Diffuse radiation on the horizontal
- Direct normal radiation
- Wind speed
- Dry-bulb temperature
- Sunshine duration
- Relative humidity

The selection criteria for the Test Reference Years are described in a report in which various selection methods are summarised and compared (Lund 1980, with Appendix G by Dogniaux and Sneyers). The criteria include statistical tests relating the frequency distribution and correlations between air temperature and global irradiation in each month, compared to those of the parent period.

The Short Reference Years comprise 4 x 14-day sets, one for each season, selected from the original multi-year datasets. Each set is assigned to its 3 constituent months in the proportion 4-6-4 days. The selection criteria reflect the need for true 3- to 5-day periods to relate to realistic time constants in buildings, the inclusion of cold and warm periods and the matching of the power spectrum of the SRY with that of the parent multiyear set. Selection was based on daily sums of direct normal irradiation.

TRY and SRY tapes have been produced for 29 locations in the European Community. These include the following 6 in the British Isles:

- Kew
- Aberporth
- Eskdalemuir
- Aldergrove
- Dublin
- Valentia

For the 4 UK stations the parent period was 1959-68, for Dublin 1969-79 and for Valentia 1951-75. All the datasets include hourly global and diffuse irradiation, except for Dublin where these were estimated. In all cases direct normal irradiation is derived. The different procedures used for deriving normal irradiation values from global irradiation and other parameters have been reported (Lund, 1985b). The TRY for Valentia existed prior to the EC work, and was selected on different criteria.

The content and format of the data for both TRY and SRY, as supplied on tape, is shown in Table 4; the data are also available on diskettes for IBM/PCs and compatibles, with some of the 'housekeeping' fields omitted, as described in the footnote to the Table. The data and manual can be bought from the UK Meteorological Office, London Road, Bracknell RG12 2SZ, or for the Irish stations from the Eire Meteorological Service, Glasnevin Hill, Dublin 9 (Tel: 0001 42 44 11).

For information, the full range of 31 sites in various European countries is shown in Figure 3. Germany was excluded from this set, being covered by its own system.

PCL Test Reference Year and Short Reference Year

Devised specifically as standard climate files for simulations of passive solar buildings using SERI-RES, the PCL-TRY and SRY were proposed by the Polytechnic of Central London, under contract to ETSU (Loxsom, 1986). The PCL-TRY is an artificial calendar year drawing typical months from different years, like the EC-TRY. It is based on analysis of:

Total irradiation on horizontal surface
Dry-bulb temperature

Selection of both TRY and SRY is based on three statistical indicators, expressing the relationship between the means, distributions and insolation/temperature correlations of the period under consideration (either whole months or shorter sequences of days) and those of the parent period (in the case of Kew, 1959 - 1968). Unlike the EC-SRY, the PCL-SRY consists of 3, 5 or 7 days selected from each month. Recent comparisons of the applicability of both the PCL- and EC-SRYs (Waide and Norton, 1989), based on SERI-RES simulations, have suggested that the 5-day/month PCL-SRYs are probably better overall than the 3-day/month or 7-day/month variants.

The TRY and SRY for Kew have been prepared as SERI-RES meteorological input files, containing the data shown in Tables 5 and 6. These may be available for selected validation work. Contact:

Energy Technology Support Unit
AERE Harwell
OX11 ORA

TEL: 0235 43 28 01 (DL)
TEL: 0235 83 46 21, X 2801 (SB)
TLX: 83 135
FAX: 0235 43 29 23

ETSU Design Days

To complement the extended set of 15 Example Weather Years identified for annual energy assessment in ETSU passive solar studies, a set of 3 types of 'design day' was selected as a basis for assessing heating and cooling plant size:

Winter (cold cloudy): related to highest heating load;

Spring (cold sunny): related to likely highest solar gains;

Summer (hot sunny): related to highest cooling load.

Hourly data for these design days were derived from information in the CIBSE Guide and other sources, with the aim of achieving consistency and enabling direct comparison between maximum heating and cooling loads.

Design days for the 15 sites are obtainable from FACET Ltd on diskette, as described in the section on 'CIBSE Example Weather Years'. There is also a separate set of design days prepared for ETSU for passive solar applications (Loxsam, 1986), in parallel with the PCL TRY and SRY.

ETSU Handbook 'CLIMATE IN THE UNITED KINGDOM'

This Handbook (Page and Lebens, 1986, available from HMSO) contains 1-day sequences of hourly data on solar irradiation and on wet- and dry-bulb temperature in printed form, in addition to a wide range of climate statistics relating to energy use in buildings. It has a particularly full coverage of irradiation data for non-horizontal surfaces: nearly all of these are artificial data, estimated at the University of Sheffield using methods developed jointly with other workers in the EC. The work was done under contract to ETSU.

The hourly data comprise typical days (for irradiation, identified as the 15th of the month in terms of solar geometry) for each month of the year, qualified by sky conditions. The following datasets are included:

Hourly clear sky incident direct normal, diffuse and global solar irradiation

Hourly incident direct normal, diffuse and global solar irradiation, averaged over all weather conditions,

Hourly overcast sky diffuse irradiation (limited data)

Hourly clear sky average dry-bulb air temperature

Hourly overcast sky average dry-bulb air temperature

Hourly wet- and dry-bulb air temperature, averaged over all weather conditions,

While 3 main types of day (clear-sky, overcast sky and average) are common to the 2 meteorological elements, the data on irradiation and air temperature cannot be regarded as truly coincident, although it may serve as a reasonable approximation.

For each of the 2 main types of irradiation day, data tables are given for 12 differently oriented surfaces, as follows:

N, NE/NW, E/W, SE/SW and S vertical

SE/SW tilts 22.5°, 45° and 67.5°

S tilts 22.5°, 45° and 67.5°

Horizontal

Data for overcast skies are given only for horizontal surfaces.

In using precomputed slope irradiation data it is important to realise that they are based on an unobstructed hemisphere of sky, and have therefore to be regarded as the highest clear-day or average values likely to be incident upon the surfaces of a building. Few actual buildings in the UK are placed on totally unobstructed sites, and irradiation on vertical and steeply tilted surfaces is much more sensitive to obstacles than irradiation on the horizontal. Where obstructions need to be taken into account it will be necessary to base calculations on the sky radiance distributions from which these Handbook data were derived (see Page, Thomson and Simmie, 1984; Page, 1986).

The Handbook gives full datasets for:

Aberdeen
Glasgow
Manchester
London
Plymouth

and a selection of datasets for:

Aberporth
Belfast
Cambridge
Cardiff
Birmingham
Newcastle
Lerwick
Sheffield

CIBSE Banded Data

Devised by BRE primarily for use in the admittance procedure, the banded data given in Table A2.7 of the CIBSE Guide, Part A2 (CIBSE, 1982) allow estimation of the daily course of dry- and wet-bulb temperatures. The estimate is a sinusoidal approximation, but has the merit of giving values that can be treated as coincident to the course of radiation for the class of day used (defined in terms of bands of values of total solar radiation). Thus appropriate runs of coincident meteorological data to be determined for a given risk of exceedence.

Background to Estimation of Irradiation in SERC, ETSU and EC work

Users may wish to explore the methods recommended in recent comprehensive studies of ways of predicting irradiation on sloping surfaces, and related matters. For example, estimated data may be required for locations other than those documented, or it may be necessary to consider sky radiance (rather than precomputed surface irradiation) if accurate account is to be taken of the effects of obstructions. Accurate information on solar geometry may also be required for the correct determination of derived solar quantities such as direct normal irradiation. The key sources are the 2nd volume (Algorithms) of the Handbook on the SERC meteorological database (2nd edition, Page and Sharples, 1988) and the final report on the collaborative EC solar radiation programme (Page, 1986). The list of contents of the SERC Algorithms Handbook is listed as Appendix A to this Report.

A point to note is that, although it does not include hourly data, Part 2 of the European Solar Radiation Atlas (Palz, 1984) contains monthly and annual climatic data derived on the same basis as those in the ETSU Handbook, using the common EC methodology. There are very minor differences (in the last significant figure) between those data common to both the ETSU Handbook and the Atlas, due to differences in rounding the estimated values.

Data on Daylight

Although the models examined in the validation exercise did not deal with daylighting, it is likely that interactions between thermal and lighting performance will arise in practice. It is therefore worth noting some sources of data on daylight.

Continuous measurements of daylight have been made during certain periods by the Meteorological Office and by building researchers, but there are no long-term records. The main sources are:

Meteorological Office

Hourly data on horizontal illuminance in Local Apparent Time (LAT), held in radiation data sets (coded L and F in Table 1) for:

Aldergrove	1972-06-01 to 1977-12-30
Bracknell	1965-02-01 to 1977-12-30
Eskdalemuir	1958-05-01 to 1977-12-30
Jersey	1969-01-01 to 1977-12-30
Kew	1950-01-01 to 1978-02-28
Lerwick	1958-05-01 to 1977-10-31
London WC	1958-06-01 to 1978-02-28

Building Research Establishment:

1 Climatological daylight data in the BRE Report 'Availability of Daylight' (Hunt, 1979): comprehensive statistics are given for total and diffuse illuminance on the horizontal at Kew and Bracknell, with some total illuminance data for Aldergrove, Eskdalemuir, Jersey, Lerwick and London Weather Centre.

2 Two finely resolved datasets recorded by Littlefair at Garston:

a Total and diffuse illuminances on horizontal and vertical external surfaces (facing N, S, E and W), together with simultaneous illuminances on 6 surfaces in 4 model rooms with openings facing N, S, E and W: period 1981-02 to 1984-03, logged every minute on weekdays and every 3 minutes at weekends from 08:30 to 17:30 GMT;

b Total and diffuse illuminances on horizontal, plus total illuminances on vertical external surfaces (facing N, S, E and W), together with simultaneous total and diffuse solar irradiances: period 1984-04 to 1985-03, logged every minute on weekdays and every 3 minutes at weekends for all daylight hours.

University of Nottingham, recorded by Tregenza at Nottingham

Total and diffuse illuminances on horizontal, plus total illuminances on vertical external surfaces (facing N, S, E and W), together with simultaneous total and diffuse solar irradiances: and simultaneous illuminances in model rooms: period 1984-06 to 1985-08: data were sampled at 2.5° intervals of solar altitude.

The expectation is that improved models of the luminous efficacy of solar radiation developed following these recent measurements will allow prediction of daylight levels from standard radiation data to an accuracy sufficient for most needs. The intention of International Daylight Measurement Year (1991) is to undertake similar work throughout the world, to allow daylight/solar radiation relationships to be verified for all climates.

Time Standards for Hourly Data

Two principal aspects of time standards may require attention:

whether data are declared in relation to zone time (GMT throughout the year) or to local apparent time (LAT), and

whether means or totals are centred on the hour, or begin or end on the hour.

Both these issues arise when radiation data need to be combined with other types of meteorological data. For all meteorological elements, it is also important to check the day-block convention used or needed, as described in 'Conventions for day-blocks' below.

Zone time and local apparent time

All UK meteorological observations except radiation and sunshine amounts refer to GMT: this itself needs to be allowed for in simulation when occupancy times are affected by Summer Time.

UK radiation measurements are recorded and archived in LAT, and need to be adjusted for the longitude of the place of measurement and the equation of time if they are to be correctly merged with other meteorological data. If required the Meteorological Office will perform this conversion when supplying data.

Averaging and accumulation of continuously recorded data

Traditionally, meteorological observations were taken as spot values on the hour. Some elements, such as rainfall, have always been totals accumulated over the period since the previous observation. In the case of a highly variable element such as wind speed or direction, it was necessary to take the mean of a short period of observation, typically the last 10 minutes of the preceding hour. More recently continuous anemograph records or fully automated logging systems have been used, in which case the average is taken over the whole of the preceding hour, but still logged as the data for the 'hour ending', in the same way as accumulated values.

Radiation meteorology is concerned in the main with measuring spot values, which are then averaged and allocated to an hour in LAT. A complication is that most models state or imply that meteorological data should be hour-centred rather than hour-ending. The result is that meteorological data for simulation generally need to be based on GMT, but centred on the hour - a practice differing from the conventions adopted by UK meteorologists (for example, LAT for radiation data, or hour-ending values for rainfall or wind data). The exception is the UK version of SERI-RES, which requires data in LAT and hour-centred.

These points were addressed in preparing the SERC meteorological database: the differences from Meteorological Office data are shown in Table 11.

Conventions for day-blocks: 'hour-beginning' and 'hour-ending' systems

Hourly weather datasets (which may carry no explicit labels for hour of day in each 24-hour set or 'day-block') need to be correctly synchronised with the course of each day in simulation, so that they can be matched with solar angles and occupancy times. There are no universal standards either for source data or for simulation models: 3 main differences may arise:

some conventions take a day as beginning at 00:00, others at 01:00;

midnight may be assigned to either the previous or following calendar date;

averaged or accumulated data may be described as either 'hour-beginning' or 'hour-ending'.

For many purposes, including its radiation and multiparameter datasets, the Meteorological Office assigns midnight to the following rather than the previous day. This follows an international convention on the exchange of synoptic data. In these datasets a particular day (assigned to a calendar date or other serial system such as year-day or century-day) will run from 'hour ending 00:00' to 'hour ending 23:00'. However, some single-parameter datasets such as hourly rainfall are based on a day running from 'hour ending 01:00' to 'hour ending 24:00'. The Meteorological Office will discuss the convention needed by a user when supplying data.

A detailed description of definitions of time is given by Lomas, Parand and Eppel (1989). They describe the treatment of weather data in various models, with particular reference to definition of the first time-step in a day, differences between original and UK versions involving a half-hour time shift in weather data files and problems of inconsistencies in time-steps for weather data, occupancy schedules and reported outputs.

Data Formats and Conversions

The formats of various types of ASCII weather data file are given as Tables. 3 data sources (SERC, ETSU and EC-TRY) are shown in Tables 2 to 4, and meteorological data files for 4 simulation programs (SERI-RES (2 variants), ESP, DEROB and HTB2) in Tables 5 to 9 . In the main the differences involve tabular layout, the order in which meteorological elements are listed and the units used for irradiation, temperature and wind speed. However in some cases conversion of data from one format to another involves more subtle differences, as described in Lomas (1989) and Whittle (1989). For the record, the full format of the US (NOAA) TMY files (of which the SERI-RES/SUNCODE format given in Table 5 is a subset) are shown in Table 10.

Some programs include conversion routines allowing them to accept weather data files in more than one format. BLAST contains the WIFE (Weather Information File Encoder) utility, which accepts inputs in various US file formats and includes routines for handling missing values and bad data, and some forms of estimation. Its output files are compiled for use in the model, and are therefore not listed as a Table in this report.

Several independent programs have been written to convert data from source formats to the input file formats of simulation programs, and between different input file formats. Of the following conversion routines, those marked with an asterisk are listed in full in the Appendix to Section 24.1 of the BRE/SERC validation report (Whittle, 1989).

From source files to program datafiles:

METCON.F77*	Converts SERC datafiles into SERI-RES or ESP formats; Authors: A Irving, SERC/J Whittle, University of Nottingham; Machine: PRIME
Set of programs	Converts SERC datafiles into SERI-RES format; Author: R Lowe/C Gibbons, University of Sheffield; Machines: IBM/PC
TRYSERI.FTN	Converts EC-TRY datafiles into SERI-RES format; Author: G Peckett, BRE; Machine: PRIME
CONVERT	Converts EC-TRY datafiles into SunCode format; Author: O Morck, Thermal Insulation Laboratory, Lyngby, Denmark; Machine IBM/PC; Language: Pascal
TRYESP.F77	Converts EC-TRY datafiles into ESP format; Author: J Clarke, University of Strathclyde; Machine: PRIME
METBAS	A utility within HTB2 for reading in climatic data and updating its met. database
PCLDTOHTB2.F77	Converts PCL ASCII weather data file to HTB2.

From one program datafile format to another:

SERIESP.F77 (formerly COPCON.FTN*)	SERI-RES to ESP; Author: M Gough, BRE; Machine: PRIME
ESPSERI.F77*	ESP to SERI-RES; Author: T Doocey, BRE; Machine: PRIME

For access to these programs please contact the originating organisations.

In future it may be possible to agree a common format for the exchange of weather data, either at national level or through European or International Standards Bodies. A recent initiative by the World Meteorological Organization (WMO), known as 'CLICOM', is intended to provide a vehicle for the storage and exchange of meteorological and climatological data in computerized form, using IBM/PCs and equivalents.

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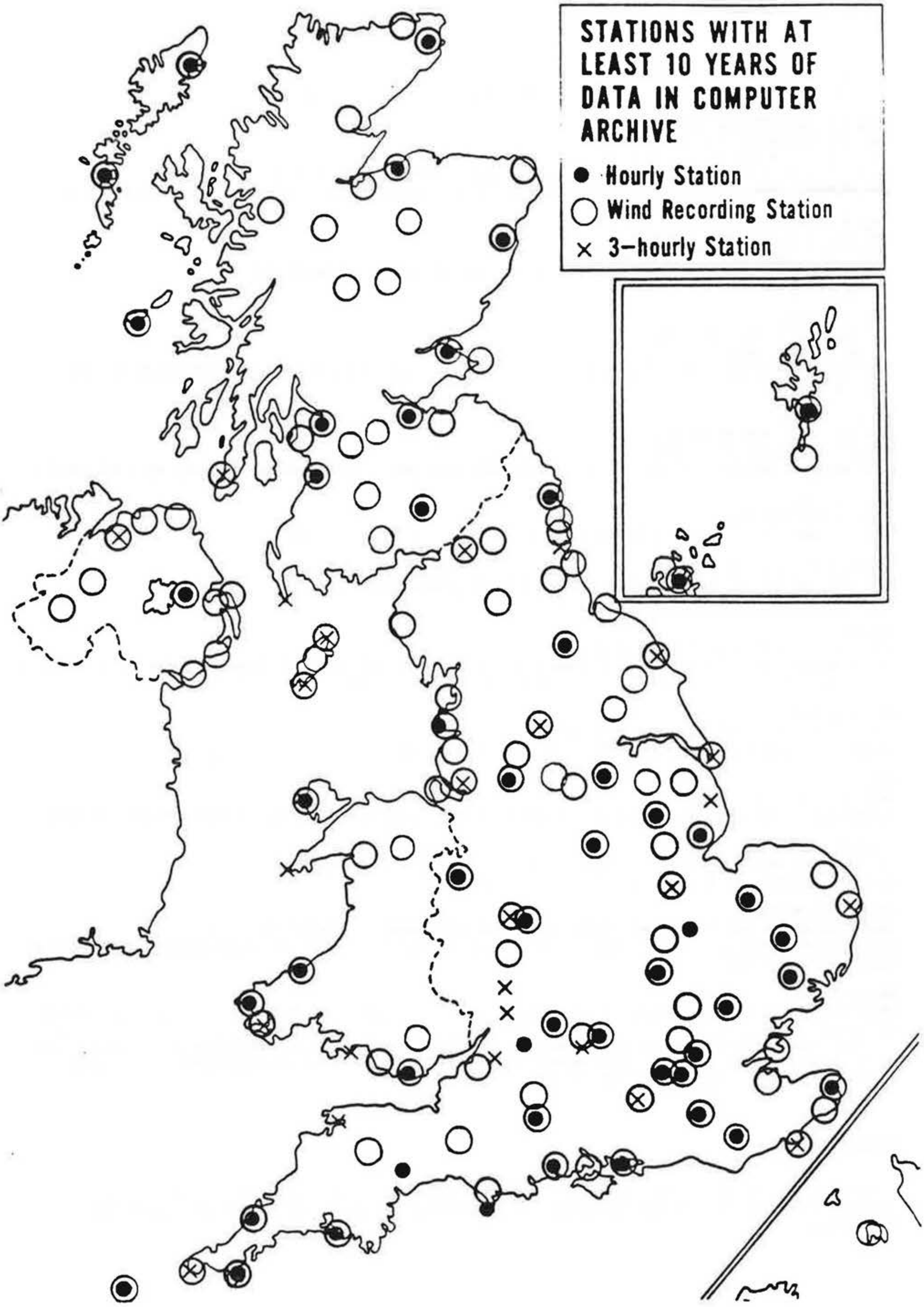

Figure 1: UK STATIONS WITH AT LEAST 10 YEARS OF DATA IN METEOROLOGICAL OFFICE ARCHIVE (Source: Meteorological Office, Bracknell)

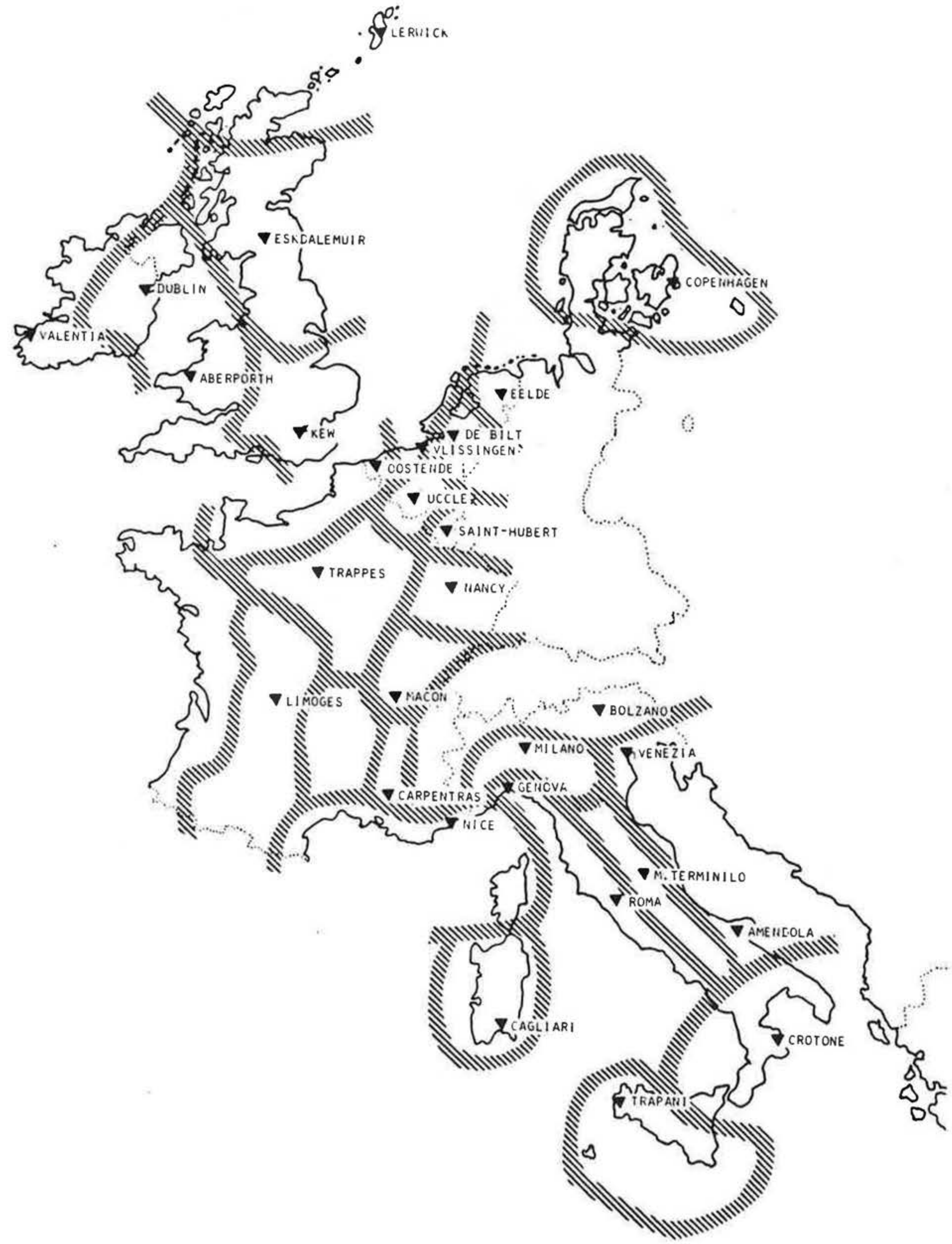

Figure 2: EUROPEAN SITES IN THE EC TRY/SRY SET (Source: Hans Lund/CEC DG XII)

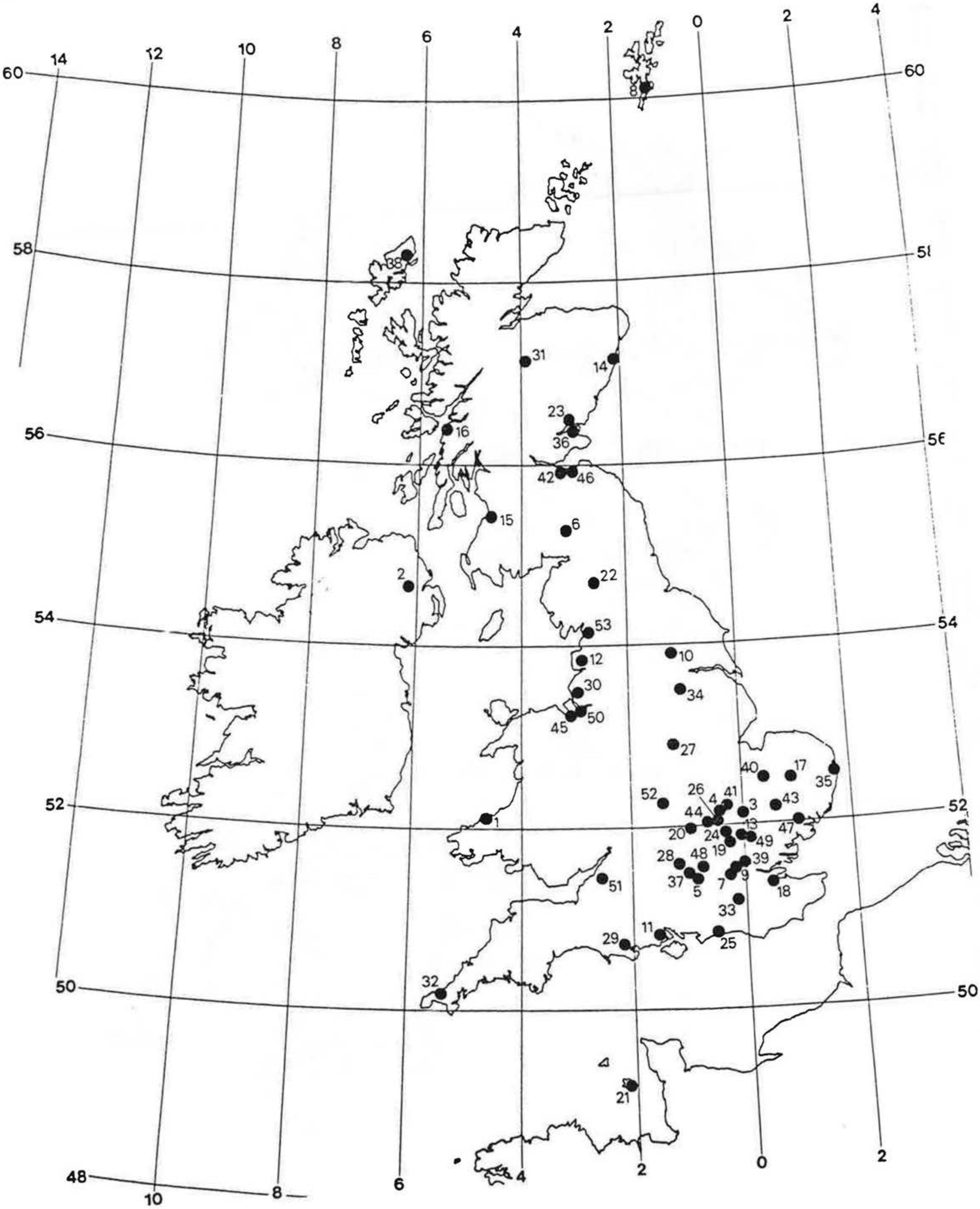

Figure 3: UK SOLAR RADIATION STATIONS
(Source: Meteorological Office, Bracknell)

No on map	Station Name	Elements Measured	Daily (d) or Hourly (h)
1	Aberporth	GD SS	h
2	Aldergrove	GDB SS L	h
3	Cambridge	GD SS	h
4	Cardington	GD SS	h
5	Easthampstead	GD SS NSEW I LF M	h
6	Eskdalemuir	GD SS L B I	h
7	Kew	GDBI SS F L	h
8	Lerwick	GD SS L B MI NSEW	h
9	London Weather Centre	GD SS L	h
10	Cawood	G	h
11	Efford	G SS	d
12	Fairfield	G SS	d
13	Hoddesdon	G SS	d
14	Aberdeen	G SS	h
15	Aunchincruive	G SS	d
16	Dunstaffnage	G	h
17	East Harling	G	d
18	East Malling	G SS	d
19	Garston	G SS	d
20	Grendon Underwood	G SS	d
21	Jersey (Channel Isles)	GD SS B L	h
22	Moorhouse	G SS	h
23	Mylnefield	GB	h
24	Rothamsted	G	d
		SS	h
25	Rustington	G SS	d
26	Silsoe	G SS D	d
27	Sutton Bonington	G SS	d
28	Wallingford	G SS	d
29	Wareham	G	d
30	Aughton	GD SS	h
31	Aviemore	GD SS	h
32	Camborne	GD SS	h
33	Crawley	GD SS	h
34	Finningley	GD	h
		SS	d
35	Hemsby	GD SS	h
36	Shanwell	GD SS	h
37	Shinfield Green	G	d
38	Stornoway	GD SS	h
39	Coppermills	G	d
40	Denver Sluice	GD SS	d
41	Grafham Water	G	h
42	Edinburgh	G SS	d
43	Brooms Barn	G SS	d
44	Woburn	G	d
45	Capenhurst	G	d
46	East Craigs	G	d
47	Great Horkesley	G	d
48	Hurley	G	h
49	Ryemeads	G	d
50	Thornton	GD	d
51	Long Ashton	G SS	d
52	Wellesbourne	G SS	d
53	Hazelrigg	G	d

Notes:-

G - Global Radiation
D - Diffuse Radiation
I - Direct Radiation
M - Radiation on a South Facing Surface inclined at the latitude angle of the station
NSEW - Radiation on Vertical Surfaces facing North, South, East and West respectively
L - Total Illumination on a Horizontal Surface (past records only - no longer measured)
F - Diffuse Illumination on a Horizontal Surface (past records only - no longer measured)
B - Radiation Balance (Incoming minus outgoing radiation (Short and Long Wave))
SS - Duration of Bright Sunshine in hours and tenths, measured by a Campbell-Stokes Sunshine Recorder

MGDBI NSEW are expressed in milliwatt - hours per square centimetre
LF are expressed in kilolux-hours

Key to Locations in Figure 3

(see also fuller details of hourly solar radiation statiosn in Table 1

Table 1: HOURLY SOLAR RADIATION STATIONS IN THE UNITED KINGDOM

STATION	LATITUDE	LONGITUDE	ELEVATION ABOVE SEA LEVEL (m)	ELEMENTS MEASURED (see Key)	PERIOD ELEMENTS MEASURED
A: Meteorological Office Data Logging Equipment (MODLE) Stations					
LERWICK (8)	60:08N	01:11W	82	T,D	1952-01 - date
				SS	1952-02 - date
				L	1958-05 - 1977-10
				B	1963-12 - 1984-10
				I,N,S,E,W	1980-11 - date
				M	1980-12 - date
ESKDALEMUIR (6)	55:19N	03:12W	242	T,D,SS	1956-01 - date
				L	1958-05 - 1977-12
				B	1964-02 - date
				I	1980-11 - date
*ALDERGROVE (2) (Belfast Airport)	54:39N	06:13W	68	T,D,B,SS	1968-10 - date
				L	1972-06 - 1977-12
CAMBRIDGE (3)	52:13N	00:06E	23	T,D,SS	1957-01 - 1971-12
*ABERPORTH (1)	52:08N	04:34W	134	T,D,SS	1957-07 - date
CARDINGTON (4)	52:06N	00:25W	28	T	1972-01 - 1981-03
				D	1972-01 - 1981-02
				SS	1972-01 - 1980-05
LONDON WEATHER CENTRE (9)	51:31N	00:07W	77	T,D,SS	1958-01 - date
				L	1958-06 - 1978-02
KEW (7)	51:28N	00:19W	5	T,D,I,SS	1947-01 - 1980-09
				L	1950-01 - 1978-02
				B	1958-01 - 1980-09
				F	1962-01 - 1974-01
BRACKNELL (5) (Easthampstead)	51:23N	00:47W	73	T,D,SS	1965-02 - date
				L,F	1965-02 - 1977-12
				N,S,E,W	1967-01 - date
				I	1974-10 - date
				M	1980-11 - date
CRAWLEY (33)	51:05N	00:13W	144	T,D,SS	1980-01 - date
HEMSBY (35) (Norfolk)	52:41N	01:41E	13	T,D,SS	1981-04 - date
CAMBORNE (32)	50:13N	05:19W	88	T,D,SS	1981-10 - date
SHANWELL (36) (Fife)	56:26N	02:52W	4	T,D	1981-12 - date
				SS	1982-01 - date
AUGHTON (30) (Lancs)	53:33N	02:55W	55	T,D,SS	1981-11 - date
STORNOWAY (38)	58:13N	06:19W	9	T,D	1982-11 - date
				SS	1982-09 - date

*FINNINGLEY (34) (Yorks)	53:29N	01:00W	10	T,D SS	1982-11 - date 1984-01 - date
AVIEMORE (31)	57:12N	03:50W	240	T,D,SS	1983-08 - date

B: Additional Recording Stations

JERSEY (21)	49:11N	02:11W	85	T,D,SS L B	1968-01 - date 1969-01 - 1977-12 1969-01 - 1978-06
*ABERDEEN UNIV. (14) (Dyce)	57:10N	02:05W	35	T SS	1967-06 - date 1980-01 - date
*DUNSTAFFNAGE (16) (nr Oban)	56:28N	05:26W	3	T	1970-04 - date
*DUNDEE (23) (Mylnefield)	56:27N	03:04W	30	T B	1973-07 - date 1973-07 - 1981-12
*MOORHOUSE (22) (nr Penrith)	54:41N	02:23W	562	T	1977-09 - 1980-05
*HURLEY (48) (nr Maidenhead)	51:32N	00:49W	43	T	1969-08 - 1972-09
*CAWOOD (10) (nr Selby)	53:50N	01:08W	6	T	1981-10 - date
THORNTON (50) (Cheshire)	53:18N	02:50W	23	T,D	1977-11 - 1982-12
*GRAFHAM WATER (41) (nr Huntingdon)	52:17N	00:19W	52	T	1981-10 - 1986-12

Note 1: In Column 1:

for stations marked with *, daily solar radiation data exist for other dates;

numbers in brackets refer to location shown in Figure 3 (Map of UK solar radiation stations).

Note 2: The letter symbols in Column 5 have the following meanings:

T Total (Global) solar irradiation on a horizontal surface

D Diffuse solar irradiation on a horizontal surface (Total irradiation with the direct component from the sun removed by a shade ring)

B Radiation balance (incoming minus outgoing radiation - short and long wave)

I Direct component of solar irradiation at normal incidence (ie on a plane at right-angles to the sun's rays)

N,S,E,W Total solar irradiation on vertical surfaces facing North, South, East and West respectively

SS Duration of bright sunshine in hours and tenths, measured on a Campbell-Stokes sunshine recorder

M Total solar irradiation on a south-facing surface inclined at the latitude angle of the station

L Total illumination on a horizontal surface (measured on an illuminometer having a spectral response similar to the human eye)

F Diffuse illumination on a horizontal surface

Note 3: This Table appears as Table 1 in 'Solar Radiation available from the Meteorological Office', issued periodically by the Meteorological Office, Bracknell giving details of measurements, calculations, hourly and overseas data

CONTENT AND FORMATS OF 3 TYPES OF METEOROLOGICAL DATA SOURCE FILE

Table 2: SERC Meteorological Database

Parameter	Unit	Format	Column
Total horizontal irradiation	W/m^2	I6	002 - 007
Diffuse horizontal irradiation	W/m^2	I6	008 - 013
Sunshine duration	0.1 h	I6	014 - 019
Dry-bulb temperature	°C	I6	020 - 025
Wet-bulb temperature	°C	I6	026 - 031
Atmospheric pressure	0.1 mb	I6	032 - 037
Wind speed	0.1 m/s	I6	038 - 043
Wind direction	° from N	I6	044 - 049
Rainfall	0.1 mm	I6	050 - 055
Rainfall duration	min	I6	056 - 061
Present weather, cloud amount	code	I6	062 - 067
Date (at 00:00 only)	DDMMYY	I6	068 - 075

Table 3: CIBSE Example Weather Years (ETSU/Facet)

Parameter	Unit	Format	Column
Station identifier		A4	001 - 004
Dry-bulb temperature	0.1°C	I4	005 - 008
Wet-bulb temperature	0.1°C	I4	009 - 012
Total horizontal irradiation	W/m^2	I4	013 - 016
Diffuse horizontal irradiation	W/m^2	I4	017 - 020
Direct normal irradiation	W/m^2	I4	021 - 023
Cloud cover	oktas	I1	024
Wind speed	0.1 m/s	I4	025 - 028
Wind direction	° from N	I2	029 - 030
Atmospheric pressure	0.1 mbar	I5	031 - 035
Artificial data indicator		A2	036 - 037
Date	YYMMDD	I6	038 - 043
Hour (1 - 24 Local Standard Time)	HH	I2	044 - 045

Table 4: EC-TRY and EC-SRY

Parameter	Unit	Format	Column
Station identifier		A3	001 - 003
Time indicator (for radiation)	L* or T*	A1	004
Dry bulb temperature	0.1°C	I4	005 - 008
Total horizontal irradiation	J/cm^2	I4	009 - 012
Diffuse horizontal irradiation	J/cm^2	I4	013 - 016
Direct normal irradiation	J/cm^2	I4	017 - 020
Sunshine duration	mins	I4	021 - 024
Relative humidity	%	I4	025 - 028
Wind speed	0.1 m/s	I4	029 - 032
Artificial data indicator		A2	033 - 034
Date	YYMMDD	I6	035 - 040
Hour (1 - 24 Local Standard Time)	HH	I2	041 - 042

* where L = Local Standard Time (GMT), and T = True Solar Time (LAT)

NB: EEC TRYs and SRYs are also available on floppy disks for PCs; on these the fields 'time indicator', 'artificial data indicator' and 'year' are omitted, giving a total record length of 35

CONTENT AND FORMATS OF METEOROLOGICAL DATA FILES FOR VARIOUS PROGRAMS

Table 5: SERI-RES and SUNCODE-PC (NOAA-TMY format, selected variables)

Parameter	Unit	Format	Column
Direct normal irradiation	kJ/m^2	I4	025 - 028
Total horizontal irradiation	kJ/m^2	I4	055 - 058
Dry bulb temperature	0.1°C	I4	104 - 107
Dew point temperature	0.1°C	I4	108 - 111
Wind speed	0.1m/s	I4	115 - 118

NB: Table 10 lists the full NOAA-TMY format

Table 6: SERI-RES and SUNCODE-PC (compressed ASCII format/metric)

Parameter	Unit	Format	Column
Direct normal irradiation	kJ/m^2	F4.0	001 - 004
Total horizontal irradiation	kJ/m^2	F4.0	006 - 009
Dry bulb temperature	0.1°C	F5.1	011 - 015
Dew point temperature	0.1°C	F5.1	017 - 021
Wind speed	0.1m/s	F4.1	023 - 026

Table 7: ESP

Parameter	Unit	Format	Column
Diffuse horizontal irradiation	W/m^2	I7	001 - 007
Dry bulb temperature	0.1°C	I7	008 - 014
Direct normal irradiation	W/m^2	I7	015 - 021
Wind speed	0.1m/s	I7	022 - 028
Wind direction	° from N	I7	029 - 036
Relative humidity	%	I7	037 - 042

Table 8: DEROB

Parameter	Unit	Format	Column
Dry bulb temperature	°C	F8.3	001 - 008
Relative humidity	%	F8.3	009 - 016
Atmospheric pressure	MPa	F8.3	017 - 024
Diffuse horizontal irradiation	W/m^2	F8.3	025 - 032
Direct normal irradiation	W/m^2	F8.3	033 - 040
Wind speed	m/s	F8.3	041 - 048

Table 9: HTB2

Parameter	Unit	Format	Column
Interval (time)	s	I6	001 - 006
Dry bulb temperature	°C	F5.1	007 - 012
Wind speed	m/s	F4.1	013 - 016
Wind direction	° from N	F5.1	017 - 021
Relative humidity	%	F4.1	022 - 025
Total cloud cover	oktas	F4.2	026 - 029
Diffuse horizontal irradiation	W/m^2	F5.1	027 - 031
Total horizontal irradiation	W/m^2	F5.1	032 - 036
Ground temperature	°C	F5.1	037 - 040

Table 10: Full NOAA-TMY format

Parameter	Unit	Format	Column
WBAN station number		I5	001 - 005
Date	YYMMDD	I6	006 - 011
Solar time	HHMM	I4	012 - 015
Local standard time	HHMM	I4	016 - 019
Extraterrestial radiation	kJ/m^2	I4	020 - 023
Direct normal irradiation	kJ/m^2	I5	024 - 028
Diffuse irradiation	kJ/m^2	I4	029 - 033
Net radiation	kJ/m^2	I4	034 - 038
Total irrad. on tilted surface	kJ/m^2	I4	039 - 043
Observed horiz. irrad.	kJ/m^2	I4	044 - 048
Corrected horiz. irrad.	kJ/m^2	I5	049 - 053
Standard horiz. irrad.	kJ/m^2	I4	054 - 058
Additional radiation measurements (2 flexible-use data fields)		I10	059 - 068
Minutes of sunshine	min	I2	069 - 070
Time of TD 1440 observations	HH	I2	071 - 072
Ceiling height	dm	I4	073 - 076
Sky condition	Code	I4	077 - 081
Visibility	hm	I4	082 - 085
Weather:			
Thunderstorm, etc	Code	I1	086
Rain, showers, etc	Code	I1	087
Drizzle, etc	Code	I1	088
Snow, ice crystals, etc	Code	I1	089
Snow showers, etc	Code	I1	090
Sleet, hail, etc	Code	I1	091
Fog, dust, sand	Code	I1	092
Smoke, haze, etc	Code	I1	093
Atmospheric pressure	kPa	I8	094 - 103
Dry-bulb temperature	0.1°C	I4	104 - 107
Dew point temperature	0.1°C	I4	108 - 111
Wind direction	° from N	I3	112 - 114
Wind speed	0.1 m/s	I4	115 - 118
Cloud cover	Codes	I4	119 - 122
Snow cover	Code	I1	123
Blank			124 - 132

Table 11: **Time Standards for Certain Meteorological Elements**

Parameter	Meteorological Office	SERC/ETSU/FACET
Total solar radiation, Diffuse solar radiation	Mean for hour ending* LAT; Meteorological Office can make an estimated conversion to mean for hour ending GMT or GMT+30 min, but this will not be done in supplying data, unless requested	Estimated mean for hour ending GMT+30 min+, obtained by averaging each successive pair of estimated GMT values
Sunshine duration	Total for hour ending* LAT; Meteorological Office can make an estimated conversion to mean for hour ending GMT or GMT+30 min, but this will not be done in supplying data, unless requested	Estimated total for hour ending GMT+30 min+, obtained by averaging each successive pair of estimated GMT values
Wind speed, wind direction	Mean for hour ending* GMT	Estimated mean for hour ending GMT+30 min+, obtained by averaging each successive pair of hour-ending GMT values

* See the sub-Section "Conventions for day-blocks: 'hour-beginning' and 'hour-ending' conventions", on p 13

\+ The first hour on a particular day is the hour ending 00:30.

Appendix: INDEX TO ALGORITHMS IN SERC METEOROLOGICAL DATABASE HANDBOOK, VOLUME II (Page J K, Sharples S, 2nd Edition, 1988)

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1.1	Day Number J.
1.2	Day Angle J' degrees.
1.3	Solar declination δ degrees (monthly mean values of solar radiation).
1.4	Solar declination δ degrees (monthly maximum values of solar radiation).
1.5	Astronomical daylength N_o hours.
1.6	The conversion of Local Mean Time to Local Apparent Time LAT hours.
1.7	Solar hour angle ω degrees
1.8	Solar altitude γ degrees.
1.9	Solar azimuth ψ degrees.
1.10	Wall solar azimuth angle α_F degrees.
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2.3	Rayleigh optical thickness δ_R per unit air mass.
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2.6	Atmospheric transmittance coefficient for absorption by a pathlength of air mass m q_a^m dimensionless.
2.7	Schuepp turbidity coefficient B and its relationship with the Angstrom turbidity coefficient β.
2.8	Conversion from Schuepp turbidity coefficient B to Linke turbidity factor T_L.
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7.2 Calculation of diffuse irradiance to find solar gain through glazing for monthly mean values $_{cs}D_m(\beta,\alpha)$ Wm^{-2}.

7.3 Estimation of glazing transmittance and absorptance as a function of angle of incidence for 6mm thick clear glass single and double glazing.

7.4 Estimation of the solar irradiance transmitted through clear glazing - clear skies Wm^{-2}.

7.5 Estimation of the solar irradiance transmitted through clear glazing - monthly mean values Wm^{-2}.

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8.3 The accurate determination of solar altitude and solar azimuth allowing for leap year effects and for atmospheric refraction, γ and ψ degrees.

SECTION 9 CLEAR SKY RADIANCES

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9.2 Ratio of clear sky horizontal diffuse irradiance D_c to clear sky zenith radiance L_{cz} steradians.

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SECTION 11 SUNSHINE AVAILABILITY AND RELATIVE SUNSHINE DURATION

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