DEVELOPMENT AND VALIDATION OF A WEATHER DATA GENERATION MODEL

by

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The performance of building energy systems is highly dependent on the weather. As a result, simulations of such systems are also dependent upon the weather and therefore require weather data as input, often on an hourly basis. Detailed weather data of this type do not exist for most locations. This project deals with synthetically generating hourly weather data for a location from monthly-average values of radiation, ambient temperature and humidity ratio.

A program written by Degelman[1976] was tested and examined for any weaknesses. Several modifications were made to the radiation model and an alternative model was developed for the ambient temperature. Data are generated in a manner such that their associated statistics are approximately equal to the long-term statistics at the specified location. The purpose of this research is to generate a single year of typical data, similar to a Typical Meterological Year. Statistics were compiled from 22 years of hourly weather data at three locations and compared to statistics obtained from the generation program. TMY data was also compared to the generated and long-term data. The generated data, while not an exact representation of the long-term, are similar to the TMY data in its ability to replicate the long-term statistics.

The hourly data are generated from location-independent correlations, and as a result, the generated data are at best capable of reproducing these correlations. Hence the limitations of the generated data lies in the ability of the correlations to replicate the long-term statistics of a site. Further refinement of these correlations will improve the quality of generated weather data. Location-specific tendencies, unless reflected through some other variable, are not reproduced (e.g., morning fog).

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NOMENCLATURE

A	long-term monthly-average amplitude of ambient temperature (°C)
A_{RH}	long-term monthly-average amplitude of relative humidity
acf	autocorrelation function
a_{kt}	deviation of k_t from the long-term average value for that hour, $a_{kt}=k_t-k_{tm}$
CCF	cloud cover fraction
cdf	cumulative distribution function
erf	error function
F	cumulative fraction of occurrence
F_{kt}	cumulative fraction of occurrence of hourly clearness index
F_{normal}	cumulative fraction of occurrence of a normally distributed variable
F_{RH}	cumulative fraction of occurrence of hourly relative humidity
F_{temp}	cumulative fraction of occurrence of hourly ambient temperature
H	daily global solar radiation on a horizontal surface
$\overline{H}$	monthly-average daily global solar radiation on a horizontal surface
H_d	daily diffuse solar radiation
H_o	daily extraterrestrial global solar radiation on a horizontal surface
$\overline{H}_o$	monthly-average daily extraterrestrial global solar radiation on a horizontal surface

I	hourly global solar radiation on a horizontal surface
I_d	hourly diffuse solar radiation
I_{dn}	hourly direct normal solar radiation
I_o	hourly global extraterrestrial solar radiation on a horizontal surface
I_{sc}	the apparent solar constant
K_d	diffuse transmittance coefficient
K_D	direct transmittance coefficient
k_t	hourly clearness index; the ratio of hourly global radiation on a horizontal surface to hourly extraterrestrial radiation, I/I_o
k_{tm}	long-term average value of the hourly clearness index for a particular daily clearness index, sunset hour angle and hour angle
K_t	daily clearness index; ratio of daily global solar radiation on a horizontal surface to daily extraterrestrial radiation, H/H_o
$\overline{K}_T$	monthly average clearness index; ratio of monthly-average global solar radiation on a horizontal surface to monthly-average daily extraterrestrial radiation, $\overline{H}/\overline{H}_o$
$\overline{K}_{ty}$	yearly average value of the monthly-average clearness index
m_i	i^{th} statistical moment
N	number of days in the month
pacf	partial autocorrelation function
pdf	probability density function
r_d	ratio of hourly diffuse solar radiation on a horizontal surface to daily diffuse radiation on a horizontal surface, I_d/H_d
r_t	ratio of hourly global solar radiation on a horizontal surface to daily global radiation on a horizontal surface, I/H

$\overline{RH}$	monthly-average relative humidity
$\overline{RH}_h$	monthly-average relative humidity at a particular hour
t	time (hours)
T	hourly ambient temperature
$\overline{T}$	daily-average ambient temperature
$\overline{T}_h$	monthly-average ambient temperature at a particular hour
$\overline{T}_m$	monthly-average daily ambient temperature
$\overline{T}_{max}$	monthly-average daily maximum hourly temperature
α	atmospheric extinction coefficient
α_3	moment coefficient of skewness
α_4	moment coefficient of kurtosis
χ	normally distributed stochastic variable with a mean of 0 and a variance of 1
ε	normally distributed random disturbance with mean of 0 and variance of σ^2
ϕ	coefficient in autoregressive stochastic model
θ_z	zenith angle of the sun
ρ	autocorrelation coefficient, subscript indicates lag
σ^2	variance of the normally distributed random disturbance ε_t
σ_a	standard deviation of the hourly k_t disturbances about zero
σ_d	standard deviation of the daily-average ambient temperatures about their monthly-average value
σ_{kt}	standard deviation of hourly clearness indices (k_t) about their long-term average value (k_{tm})

σ_m	standard deviation of a month's daily average ambient temperature about the long-term average value for that month
$\sigma_{m,h}$	standard deviation of a month's average ambient temperature at a particular hour about the long-term average value for that month at that particular hour
σ_{max}	standard deviation of the daily maximum dry bulb temperatures about their monthly-average value
σ_{yr}	standard deviation of the 12 monthly-average daily ambient temperatures about the yearly average daily temperature
ω	hour angle, in degrees
ω_s	sunset hour angle, in degrees