TYPE 575: SKY TEMPERATURE

General Description

This subroutine calculates an effective sky temperature based on the dew point temperature, the station pressure, the fraction of opaque cloud cover, and the emissivity of the clouds. The correlation is based on equations developed in "Characteristics of Infrared Sky Radiation in the U.S.A." (Berdahl, 1984). Such calculated sky temperatures are most commonly used in the calculation of radiation losses from structures and solar collectors.

Nomenclature

$E_{o,sky}$	[0..1]	Clear sky emissivity
T_{dewpt}	[ºC]	Dew point temperature
time	[hr]	The hour of the year (simulation time)
pressure	[millibars]	Atmospheric pressure
E_{sky}	[0..1]	Emissivity of the sky in the presence of clouds
f_{cloud}	[0..1]	Fraction of sky covered by opaque clouds
ε_{cloud}	[0..1]	Emissivity of clouds
T_{amb}	[ºC]	Ambient temperature
T_{sky}	[ºC]	Sky temperature

Detailed Description

Calculation of the sky temperature begins with an estimation of the clear sky emissivity based on the dew point temperature. In modes 2 and 4 of this component, the relative humidity is entered as an input and the dew point temperature is calculated internally. In modes 1 and 3, the dew point temperature is entered directly. The dew point correlation for clear sky emissivity is shown in Equation 575.1.

$$E_{o,sky} = 0.711 + 0.56 * \left(\frac{T_{dewpt}}{100} \right) + 0.73 * \left(\frac{T_{dewpt}}{100} \right)^2 \qquad \text{(Eq. 575.1)}$$

The clear sky emissivity is then corrected for time of day in order to account for the differences in radiative transfer between the night time black sky and the day time blue sky, as shown in Equation 575.2. In this equation, time is the hour of the year.

$$E_{o,sky} = E_{o,sky} + 0.013 * \cos\left(2\pi * \frac{MOD(time,24)}{24} \right) \qquad \text{(Eq. 575.2)}$$

The clear sky emissivity is then corrected for atmospheric pressure. While the model takes pressure as an input in atmospheres, it makes an internal conversion to millibars, the pressure units for which Equation 575.3 was developed.

$$E_{o,sky} = E_{o,sky} + 0.00012 * (pressure - 1000) \qquad \text{(Eq. 575.3)}$$

The emissivity of the sky in the presence of clouds is calculated by multiplying the clear sky emissivity by the fraction of the sky that is covered by clouds and by the emissivity of the clouds themselves, as shown in Equation 575.4. The fraction of sky covered by opaque clouds has a value between 0 (no cloud cover) and 1 (complete cloud cover). Depending upon the mode of this component, the fraction of sky covered by opaque clouds may be entered either as a value between 0 and 1 or as a percentage (0 to 100).

$$E_{sky} = E_{o,sky} + \left(1.0 - E_{o,sky}\right) * f_{cloud} * \varepsilon_{cloud} \quad \text{(Eq. 575.4)}$$

Finally, the sky temperature is computed using the correlation shown in Equation 575.5.

$$T_{sky} = E_{sky}^{1/4}\left(T_{amb} + 273.13\right) - 273.13 \quad \text{(Eq. 575.5)}$$

Example

Type575 is used in the following Simulation Studio example:
\trnsys16\TESS Models\Studio Projects\Utility Library\Utility_Misc.tpf

References

Berdahl, Martin M., *"Characteristics of Infrared Sky Radiation in the U.S.A."*, Solar Energy Journal, 33.4 (1984): 321.